AP Chem Midterm Practice Problems

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1. A sample of chlorine gas is placed in a container of constant pressure. The sample is heated until the absolute temperature is doubled. This will also double which of the following?
   a. potential energy
   b. moles
   c. density
   d. number of molecules
   e. volume

2. A balloon contains 2.0 g of hydrogen gas. A second balloon contains 4.0 g of helium gas. Both balloons are at the same temperature. Pick the FALSE statement from the following list.
   a. The number of hydrogen molecules is the same as the number of helium atoms in each balloon.
   b. The density of the helium in its balloon is greater than the density of the hydrogen in its balloon.
   c. The volume of each balloon is the same.
   d. The average speed of the molecules/atoms in each balloon is the same.
   e. The average kinetic energy of the molecules/atoms in each balloon is the same.

Choose one of the following for questions 3-5.

a. Cu^{2+}
b. CO_3^{2-}
c. Fe^{3+}
d. Al^{3+}
e. Pb^{2+}

3. This ion will form a precipitate when added to a solution of sodium sulfate. e

4. This ion gives a deep blue color when excess aqueous ammonia is added to a solution containing it. a

5. Aqueous solutions of this ion give a reddish precipitate when excess hydroxide ion is added. c

6. $$Ba + 2\,H_2O \rightarrow Ba(OH)_2 + H_2$$

Barium reacts with water according to the above reaction. What volume of hydrogen gas at standard temperature and pressure, is produced from 0.400 mol of barium. (do this **WITHOUT** a calculator)

   a. 8.96 L
   b. 5.60 L
   c. 4.48 L
   d. 3.36 L
   e. 2.24 L

7. The volume and pressure of a real gas are not the same as those calculated from the ideal gas equation, because the ideal gas equation does NOT take into account.
   a. the attraction between the molecules and the speed at which the molecules are moving
   b. the volume of the molecules and the mass of the molecules
   c. the attraction between the molecules and the mass of the molecules
   d. the volume of the molecules and variations in the absolute temperature
   e. the volume of the molecules and the attraction between the molecules

8. Aluminum metal reacts with HCl to produce aluminum chloride and hydrogen gas. What volume of hydrogen gas at STP is produced when 13.5 g of aluminum is mixed with excess HCl? (**WITHOUT** a calculator!!)

a. 22.4 L
b. 33.6 L
c. 11.2 L
d. 16.8 L
e. 7.46 L

9. A chemist need 800 mL of a 0.50 M bromide ion, Br^{1-}, solution. He has 800 mL of a 0.20 M KBr solution. How many moles of solid $MgBr_2$ will he need to add to increase the concentration to the desired value? (do **WITHOUT** a calculator)

a. 0.24
b. 0.50
c. 0.30
d. 0.12
e. 0.15

10. How many grams of HNO_3 are there in 500.0 mL of a 5.00 M solution? (Do this **WITHOUT** a calculator)

a. 31.5 g
b. 63.0 g
c. 5.00 g
d. 315 g
e. 158 g

11.

Step 1: $2\ NO_2(g) \rightarrow N_2(g) + 2\ O_2(g)$
Step 2: $2\ CO(g) + O_2(g) \rightarrow 2\ CO_2(g)$
Step 3: $N_2(g) + O_2(g) \rightarrow 2\ NO(g)$

The above represents a proposed mechanism for the reaction of NO_2 with CO. What are the overall products of the reaction?

a. N_2 and O_2
b. O_2 and CO_2
c. N_2 and NO
d. NO only
e. NO and CO_2

12. What is the coefficient of H^+ when the reaction below is balanced?

$$I^{1-}(aq) + H^+(aq) + MnO_4^{1-}(aq) \rightarrow Mn^{2+}(aq) + H_2O(l) + I_2(s)$$

a. 12
b. 32
c. 16
d. 8
e. 2

Redox!

Questions 13–16 refer to the following types of energy.

(A) Activation energy
(B) Free energy
(C) Ionization energy
(D) Kinetic energy
(E) Lattice energy

Don't worry yet!

13. The energy required to convert a ground-state atom in the gas phase to a gaseous positive ion C
14. The energy change that occurs in the conversion of an ionic solid to widely separated gaseous ions E
15. The energy in a chemical or physical change that is available to do useful work D
16. The energy required to form the transition state in a chemical reaction A

17. A hot-air balloon rises. Which of the following is the best explanation for this observation?
a. The pressure on the walls of the balloon increases with increasing temperature.
b. The difference in temperature between the air inside and outside the balloon produces convection currents.
c. The cooler air outside the balloon pushes in on the walls of the balloon.
d. The rate of diffusion of cooler air is less than that of warmer air.
e. The air density inside the balloon is less than that of the surrounding air.

Questions 18–19 refer to the following elements.

(A) Lithium
(B) Nickel
(C) Bromine
(D) Uranium
(E) Fluorine

18. Is a gas in its standard state at 298 K E
19. Reacts with water to form a strong base A

20. A 1.0 L sample of an aqueous solution contains 0.10 mol of NaCl and 0.10 mol of $CaCl_2$. What is the minimum number of moles of $AgNO_3$ that must be added to the solution in order to precipitate all of the Cl^- as $AgCl_{(s)}$? (Assume that AgCl is insoluble.) **WITHOUT** calculator

a. 0.10 mol
b. 0.20 mol
c. 0.30 mol
d. 0.40 mol
e. 0.60 mol

21. If 87.5 percent of a sample of pure ^{131}I decays in 24 days, what is the half-life of ^{131}I? (Do this **WITHOUT** a calculator!)

(A) 6 days (B) 8 days (C) 12 days (D) 14 days (E) 21 days

$$\ldots Li_3N_{(s)} + \ldots H_2O_{(l)} \rightarrow \ldots Li^+_{(aq)} + \ldots OH^-_{(aq)} + \ldots NH_{3(g)}$$

22. When the equation above is balanced and all coefficients reduced to lowest whole-number terms, the coefficient for $OH^-_{(aq)}$ is

(A) 1 (B) 2 (C) 3 (D) 4 (E) 6

$$10\ HI + 2\ KMnO_4 + 3\ H_2SO_4 \rightarrow 5\ I_2 + 2\ MnSO_4 + K_2SO_4 + 8\ H_2O$$

23. According to the balanced equation above, how many moles of HI would be necessary to produce 2.5 mol of I_2, starting with 4.0 mol of $KMnO_4$ and 3.0 mol of H_2SO_4? (**Without** calculator!!)

(A) 20. (B) 10. (C) 8.0 (D) 5.0 (E) 2.5

24. Which of the following is the correct name for the compound with formula Ca_3P_2?

a. tricalcium diphosphorus
b. calcium phosphite
c. calcium phosphate
d. calcium diphosphate
e. calcium phosphide

Questions 25-28 refer to aqueous solutions containing 1:1 mole ratios of the following pairs of substances. Assume all concentration are 1 M.

a. sodium hydroxide and ammonia
b. sodium hydroxide and hydrochloric acid
c. hydrobromic acid and potassium bromide
d. acetic acid and sodium acetate
e. methylamine and methylammonium chloride

25. A buffer with a pH of less than 7 c

26. A buffer with a pH of greater than 8 e

27. The solution with a pH of 7 b

28. The solution with the highest pH a

29. The volume of distilled water that should be **added** to 10.0 mL of 6.00 M NaOH in order to prepare a 0.100 M NaOH solution is approximately

a. 0.60 mL
b. 5.9 mL
c. 59.0 mL
d. 590. mL
e. 600 mL

30. The simplest formula for a hydrocarbon that is 20.0% hydrogen by mass is

a. CH
b. CH_2
c. CH_3
d. C_2H_2
e. C_2H_3

31. A sample fo 0.010 mol of nitrogen dioxide gas is confined at 127 °C and 2.5 atm. What would the pressure of this sample be at 27°C and the same volume?

a. 0,033 atm
b. 0.33 atm
c. 0.53 atm
d. 1.25 atm
e. 1.88 atm

32. What mass of KBr (molar mass 199 g mol^{-1}) is required to make 250. mL of a 0.400 M KBr solution? (Do this **WITHOUT** a calculator!)

a. 0.595 g
b. 1.19 g
c. 2.50 g
d. 19.9 g
e. 47.6 g

33. In a laboratory, a student want to quantitatively collect the CO_2 gas generated by adding Na_2CO_3 (s) to 2.5 M HCl. The student sets up the apparatus to collect eh CO_2 gas over water. The volume of collected gas is much less than the expected volume because CO_2 gas

a. is very soluble in water
b. is produced at low pressure
c. is more dense than water vapor
d. has a larger molar mass than that of N_2 gas, the major component of air
e. has a slower average molecular speed than water vapor at the same temperature.

34. What mass of Cu (s) would be produced if 0.40 mol of Cu_2O (s) was reduced completely with excess H_2 (g)? (Do this **WITHOUT** a calculator!)

a. 13 g
b. 25 g
c. 38 g
d. 51 g
e. 100 g

35. At which of the following temperatures and pressures would a real gas be most likely deviate from ideal behavior?

	Temperature (K)	Pressure (atm)
a.	100	50
b.	200	5
c.	300	0.01
d.	500	0.01
e.	500	1

36. Which of the following substances would produce the LEAST mass of CO_2 if completely burned in excess oxygen gas? (Do this **WITHOUT** a calculator!!)

a. 10.0 g CH_4
b. 10.0 g CH_3OH
c. 10.0 g C_2H_4
d. 10.0 g C_2H_6
e. 10.0 g C_4H_5OH

37. After 195 days, a 10.0 g sample of pure ^{95}Zr has decayed to the extent that only 1.25 g of the original ^{95}Zr remains. The half-life of ^{95}Zr is closest to (Do this **WITHOUT** a calculator!!)

a. 195 days
b. 97.5 days
c. 65.0 days
d. 48.8 days
e. 24.4 days

38. A hydrocarbon gas with an empirical formula of CH_2 has a density of 1.3 g/L at 0°C and 1.00 atm. A possible formula for the hydrocarbon is

a. CH_2
b. C_2H_4
c. C_3H_6
d. C_4H_8
e. C_5H_{10}

39. $N_2\,(g) + O_2 + Cl_2 \leftrightarrow 2\,NOCl\,(g) \qquad H^\circ = +104\ kJ\ mol^{-1}$

The equilibrium system represented above is contained in a sealed, rigid vessel. Which of the following will increase if the temperature of the mixture is raised?

a. $[N_2\,(g)]$
b. The rate of the forward reaction only
c. The rate of the reverse reaction only
d. The rates of both the forward and reverse reactions
e. The total number of moles of gas in the vessel

40. By mixing only 0.15 M HCl and 0.25 M HCl, it is possible to create all of the following solutions EXCEPT (do this **WITHOUT** a calculator!!)

a. 0.23 *M* HCl
b. 0.21 *M* HCl
c. 0.18 *M* HCl
d. 0.16 *M* HCl
e. 0.14 *M* HCl

41. $2\,HClO + 3\,O_2 \rightarrow 2\,HClO_4$

As the reaction represented above proceeds to the right, the oxidation number of chlorine changes from

a. -1 to +3
b. -1 to +5
c. +1 to +5
d. +1 to +7
e. +3 to +7

**** Feel free to use a calculator for the FRQs ****

Free Response Questions

1. Answer the following using chemical concepts and principles of the behavior of gases.

a) A metal cylinder with a volume of 5.25 L contains 3.22 g of He (g) and 11.56 g of N_2 (g) at 15.0 °C.

i) Calculate the total pressure in the cylinder.

$3.22\text{g He} \times \frac{1\text{mol}}{4\text{g}} = .805\text{mol}$ $\quad 11.56\text{g } N_2 \times \frac{1\text{mol}}{28\text{g}} = .413\text{mol}$

$P_{total} = \frac{(1.218\text{mol})(.0821)(288\text{K})}{5.25\text{L}} = 5.49\text{atm}$

ii) Calculate the partial pressure of N_2 (g) in the cylinder.

$\left(\frac{.413\text{mol}}{1.218\text{mol}}\right)(5.49\text{ atm}) = 1.86\text{ atm}$

b) A 1.50 L container holds a 9.62 g sample of an unknown gaseous saturated hydrocarbon at 30 °C and 3.62 atm. $C_n H_{(2n+2)}$

i) Calculate the density of the gas.

$D = 9.62\text{g}/1.50\text{L} = 6.41\text{g/L}$

ii) Calculate the molar mass of the gas

$mm = \frac{(6.41\text{g/L})(.0821)(303\text{K})}{3.62\text{atm}} = 44.0\text{g/mol}$

iii) Write the formula of the hydrocarbon.

C_3H_8

iv) Calculate the root-mean-square speed of the gas molecules in the container at 30 °C. (Note: 1 J = 1 kg m^2 s^{-2})

$u_{rms} = \sqrt{\frac{3(8.314)(303\text{K})}{.044\text{kg/mol}}} = 414\text{m/s}$

2. A student performs a titration in which a 10.00 mL sample of 0.0571 *M* HCl is titrated with a solution of NaOH of unknown concentration.

a) Describe the steps that the student should take to prepare and fill the buret for the titration given a wet 50.00 mL buret and the materials listed below.

0.0571 *M* HCl solution	Indicator solution
NaOH(aq) (uknown concentration)	distilled water
10.5 *M* NaOH solution	100 mL beaker

b) Calculate the pH of the 0.0571 *M* HCl.

$-\log(0.0571) = 1.24$

c) A volume of 7.62 mL of the NaOH solution was needed to reach the end point of the titration. Calculate the molarity of the NaOH solution used in the titration.

$.010\text{L} \times \frac{.0571\text{mol HCl}}{1\text{L}} \times \frac{1\text{mol NaOH}}{1\text{mol HCl}} = \frac{5.71\times10^{-4}\text{mol}}{.00762\text{L}} = .0749$

In a different titration using a different NaOH solution, the concentration of NaOH was determined by the student to be 0.0614 *M*.

d) Given that the actual concentration of the NaOH solution was 0.0627 *M*, calculate the percent error of the student's result. $\frac{|.0627 - .06141|}{.0627} \times 100 = 2.07\%$

e) Calculate the volume of the 10.5 *M* NaOH that is needed to prepare 250.0 mL of 0.0627 *M* NaOH.

$.250\,L \times \frac{.0627\,mol}{1\,L} = .01567\,mol \times \frac{1\,L}{10.5\,mol} = .00149\,L = 1.49\,mL$

3. Sulfuryl chloride, SO_2Cl_2, is a highly reactive gaseous compound. When heated, it decomposes as follows:

$$SO_2Cl_{2(g)} \rightarrow SO_2(g) + Cl_2(g).$$

This decomposition is endothermic. A sample of 3.509 grams of SO_2Cl_2 is placed in an evacuated 1.00 L bulb and the temperature is raised to 375K.

(a) What would be the pressure in atmospheres in the bulb if no dissociation of the $SO_2Cl_{2(g)}$ occurred? $3.509\,g \times \frac{1\,mol}{135\,g} = .0260\,mol$ $P = \frac{(.0260)(.0821)(375)}{1} = .800\,atm$

(b) When the system has come to equilibrium at 375K, the total pressure in the bulb is found to be 1.43 atmospheres. Calculate the partial pressures of SO_2, Cl_2, and SO_2Cl_2 at equilibrium at 375K. $SO_2 = .63\,atm$, $Cl_2 = .63\,atm$, $SO_2Cl_2 = .17\,atm$

RICE table below

(c) Give the expression for the equilibrium constant (either K_p or K_c) for the decomposition of $SO_2Cl_{2(g)}$ at 375K. Calculate the value of the equilibrium constant.

$K_p = \frac{(P_{SO_2})(P_{Cl_2})}{P_{SO_2Cl_2}} = 2.33$

(d) If the temperature were raised to 500K, what effect would this have on the equilibrium constant? Explain briefly. K would increase. Endothermic, so heat is a reactant ⇒ shift right.

	SO_2Cl_2	→ SO_2	+ Cl_2
R			
I	.800 atm	0	0
C	−x	+x	+x
E	.800 − x	x	x

$(.800\,atm - x) + 2x = 1.43\,atm$

$.800 + x = 1.43\,atm$

$x = .63\,atm$